(12) UK Patent Application (19) GB (11) 2 181 707 (13) A

(43) Application published 29 Apr 1987

(21) Application No 8425404

(22) Date of filing 8 Oct 1984

(51) INT CL⁴
G09B 9/06

(52) Domestic classification (Edition I)
B7V GA

(56) Documents cited
GB 0834662

(58) Field of search
B7V

(71) Applicant
The Singer Company (UK) Limited,

(Incorporated in United Kingdom),

27 Chartwell Road, Churchill Industrial Estate, Lancing, Sussex BN15 8UE

(72) Inventor
George Robert Bennett

(74) Agent and/or Address for Service
Reddie & Grose, 16 Theobalds Road, London WC1X 8PL

(54) Submarine motion simulator

(57) To enable pitch and roll simulation of a submarine the apparatus comprises a framework 2, pivotal about the axis XX, supported by spaced-apart A-frames 6 and 8 and an inner framework 32 carrying the chamber pivoted within the framework 2 about an axis YY. Drive for pivotal movement about axis XX is effected by a motor 15 driving a drive wheel 16 through harmonic reduction gearing 17, the wheel 16 in turn driving a toothed 'silent' multi-chain, running around idlers 20 and in meshing contact with a toothed semi-circular part 14 fixed to framework 2. The inner framework 32 is driven in an identical manner to the framework 2 i.e. by an electric motor driving arcuate member 34. All pivotal movement is restricted by tilt limiting devices.

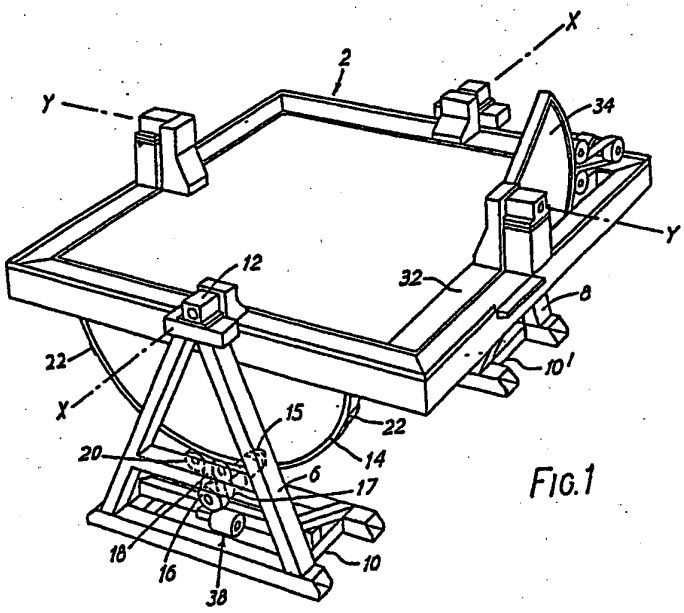

FIG. 1

GB 2 181 707 A

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

2181707

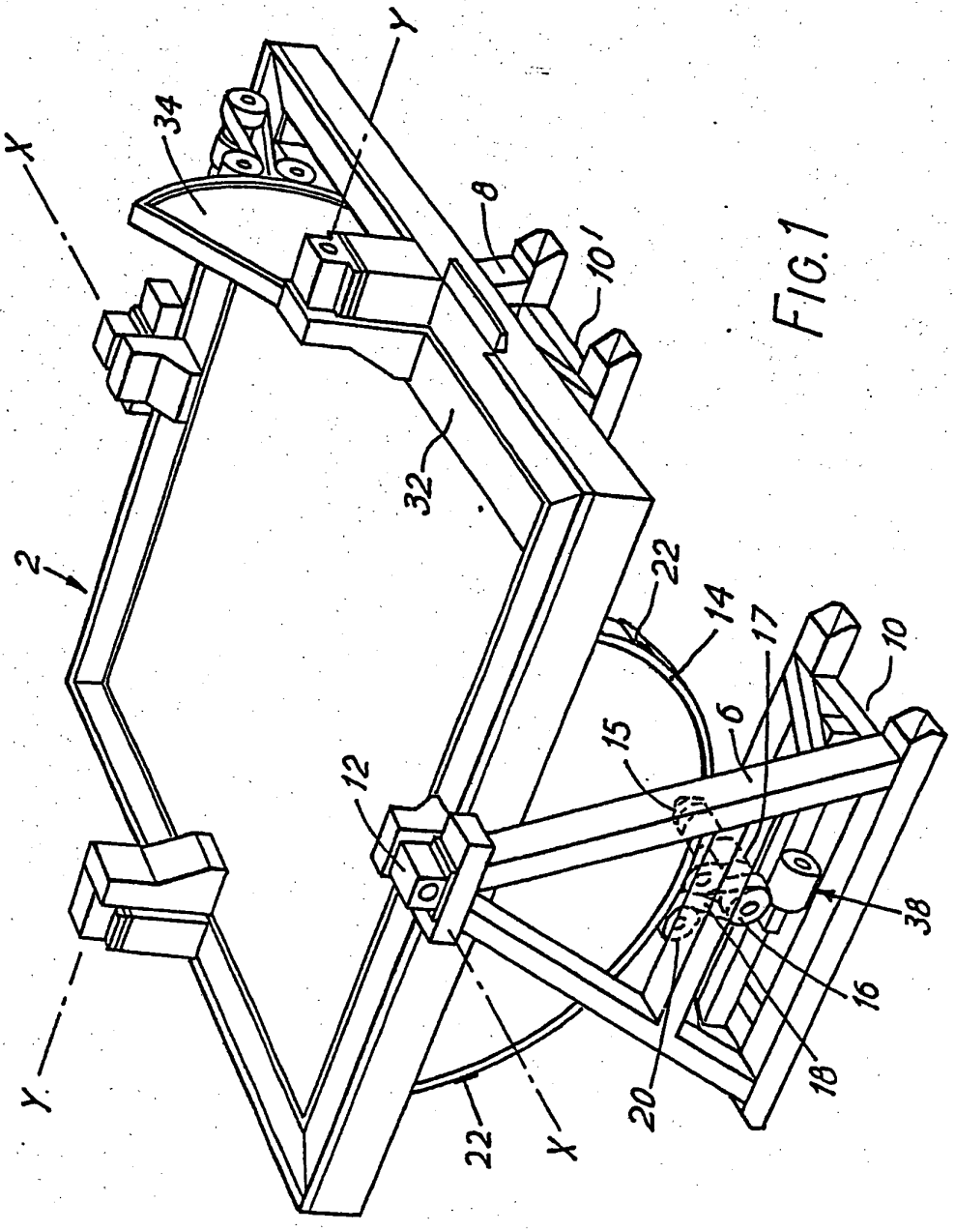

FIG.1

2181707

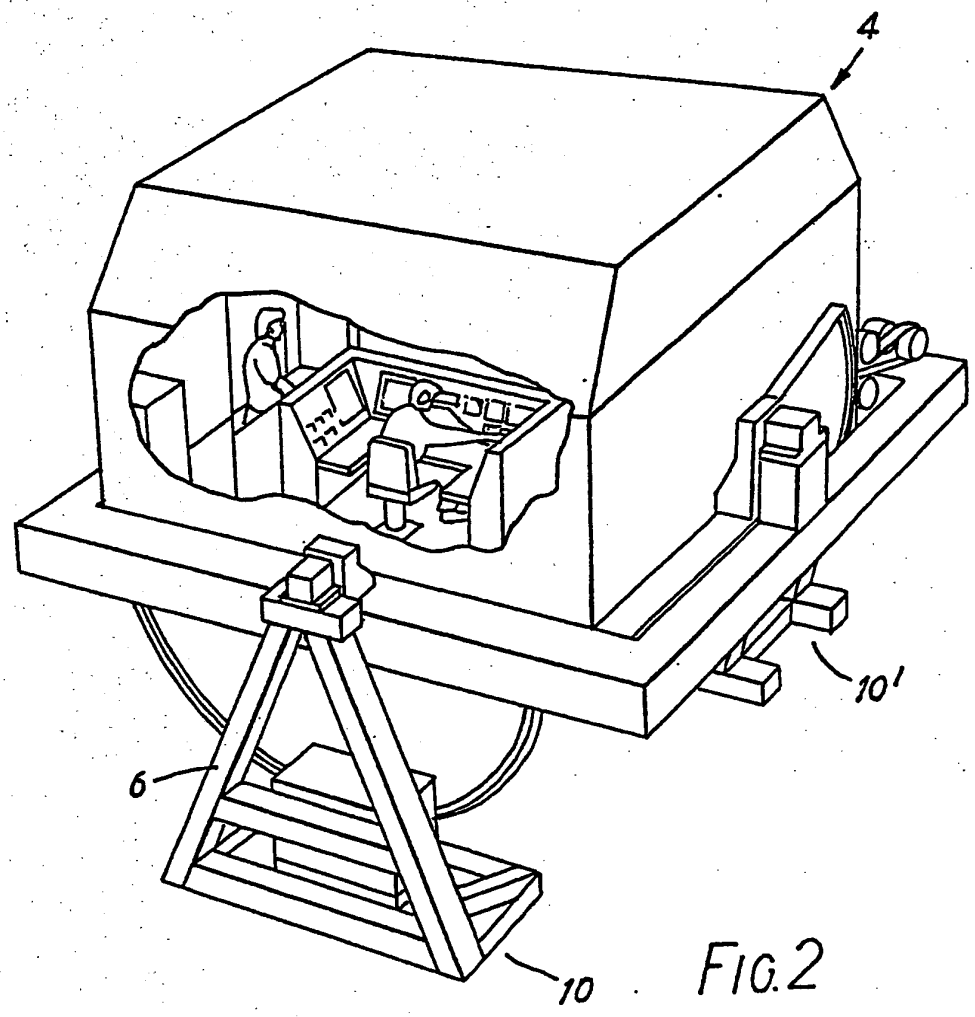

FIG.2

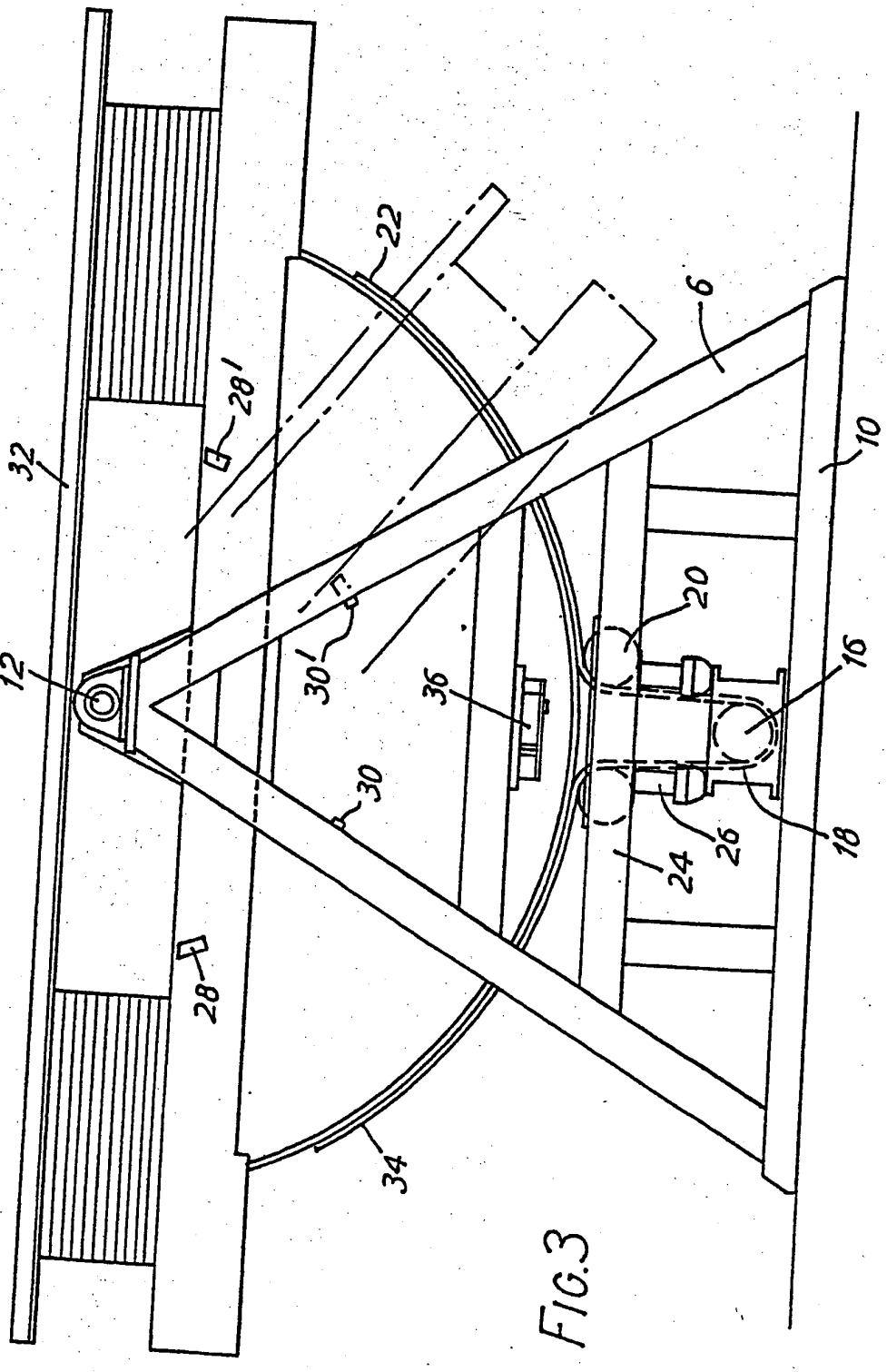

FIG.3

SPECIFICATION

Submarin moti n simulator

This invention relates to a submarine motion simulator for training and exercise purposes.

According to the invention there is provided apparatus for simulating the motion of a submarine, comprising a simulation chamber mounted for pivotal movement about first and second mutually perpendicular axes, and first and second drive means for effecting pivotal movement of the simulation chamber about the first and second axes respectively, each of the drive means comprising a part connected to the chamber and having an arcuate surface, and a belt or chain fixed at its ends to the arcuate surface and extending over the surface except in an intermediate region of the belt in which it leaves the arcuate surface and is engaged with a drive wheel driven by an electric motor.

As is well known, it is important that a submarine should be able to operate quietly underwater. The present invention enables a simulator to simulate manoeuvres in a quiet and thus realistic manner, and to undergo realistic pitch and roll (about the first and second axes respectively).

Thus it is most desirable to use smooth-running, quiet electric motors. Each motor preferably drives through quiet reduction gearing. Harmonic gearing is preferably used to provide a large reduction, in a single gearing stage.

The chain or belt used is preferably a toothed multi-chain of known, "silent" type.

Preferably each drive means further comprises a pair of idler rollers bearing against the arcuate surface at the two places where the chain or belt leaves the arcuate surface to engage the drive wheel.

Means are provided to isolate the chamber from noise and vibrations from each of the motor/gearing assemblies (preferably engaging a supporting frame on which the chamber is mounted and about which it moves).

Means are provided for limiting the pitch and roll of the chamber, i.e. the pivotal movement about the first and second axes. The limiting means may be mechanical, for example, using buffers moving with the simulation chamber and engaging buffers on an immovable part such as a supporting frame at the limits of movement. Alternatively, a microswitch or microswitches may be operated at the limits of movement, to interrupt the respective motor or motors. Another alternative is to incorporate suitable instructions in software controlling the motors.

In practice, to achieve the greater measure of safety, a combination of all three means of limiting movement is contemplated, operable in a sequence, one or two degrees of movement displaced one from another. When all three are available the software-controlled position is reached first and so is the only movement-limiting means ordinarily used. The next movement limiting means operable is preferably a microswitch, interrupting the motor, and this will be actuated only if the software-c ntrolled limit is passed. Should the microswitch fail, the buff r or buffers will arrest the movement of th chamber.

The invention will now be further described by way of example, with r ference to the accompanying drawings, in which:

Figure 1 is a perspective view of apparatus for supporting a simulated submarine chamber;

Figure 2 is a perspective view of the apparatus of Figure 1, supporting a submarine simulation chamber; and

Figure 3 is an elevation of the apparatus.

The apparatus shown in the drawings provides a gimbal mounting so that the simulation chamber 4 it supports can be pivoted about intersecting, mutually perpendicular axes XX and YY, to simulate pitch and roll. The apparatus comprises a framework 2 supported by spaced-apart A-frames 6 and 8, each of which has a wide base 10. At the top of each A-frame is a pivotal connection 12 to the framework 2, each on the pivot axis XX.

The drive means for the whole framework 2 (as opposed to the drive means just for an inner frame thereof, to be described later) comprises an externally toothed, semi-circular part 14 providing a toothed arcuate surface. The part 14 is fixed to the framework and driven by a quiet electric motor mounted on the A-frame 6. The centre of curvature of the part 14 is coincident with the pivot axis XX. The motor 15 drives a drive wheel 16, through harmonic reduction gearing 17. The drive wheel in turn drives a toothed multi-chain 18 of the "silent" type.

The chain contacts two idlers 20 above the drive wheel 16. The chain runs around the idlers and into meshing contact with the arcuate surface of the semi-circular part 14. Thereafter, the chain follows the surface of the part 14. The chain is fixed at each of its ends 22 to the part 14.

The harmonic reduction gearing 17 is of the type produced by Harmonic Drive Limited under part number HDVC 80. An internally-toothed ring gear is driven by an externally toothed, flexible annular gear with slightly fewer teeth. In the HDVC 80 the ring gear has 100 teeth and the flexible gear 98. The flexible gear is driven by an elliptical input member inside it, via a ball bearing transmission between the elliptical input member and the flexible gear. The flexible gear adopts the shape of the elliptical input member/ball bearing assembly and meshes with the ring gear at two, diametrically-opposed positions only. When the input member turns through one revolution the ring gear, which is the output member of the gearing, advances by two teeth. Accordingly the gearing provides a speed reduction of 50:1. The harmonic gearing, moreover, provides this large speed reduction quietly, in a single stage of gearing, with a high efficiency and with concentric input and output members. Accordingly the drive wheel, reduction gearing and motor output shaft have a common axis.

The silent multi-chain is of the type sold by Morse Flexon Limited, and by Ramsey Silent Chain Limited. This type of chain is typically made up along its length of chain sections each having five chain links arranged parallel to ne another. Each link has two apertures. Each apertur receives a rod which also passes through the corresponding apertures of the other four links f the chain section and through the appropriate apertures of the links of th adjoining

chain section, so as to secure the section together. Once joined tog ther the sections can flex relative to one another by a limited amount, and th chain is able to bend to a 10-inch (25 cm) diameter. The diameter of the drive wheel 16 and idlers 20 is 12 inches (30.5 cm). The chain is able to flex in a quiet manner because the shape of the apertures and the rods is such that the rods are always a tight fit in the apertures, whilst able to permit the limited flexing movement. Accordingly the chain is 'rattle free' and quiet.

The idlers 20 are polyurethane-tyred castors manufactured by Revvo Caster Co. Ltd.

The motor/gearing assembly is suspended from a strut 24 of the A-frame 6 by four resilient link members or dampers 26, two of which are shown in Figure 3. The dampers help to prevent the transmission of vibration and noise to the A-frame 6 and hence to the framework 2 and chamber 4. This suspended arrangement also assists in tensioning the chain 18.

It will be apparent that rotation of the drive wheel 16 will cause the whole framework 2 to tilt about the axis XX. For example, if the drive wheel turns clockwise, as seen in Figure 3, the righthand side of the framework will dip.

The tilting movement is terminated in either direction by software instructions for the motor. If this fails actuators 28/28' on the framework actuate microswitches 30/30' on the legs of A-frame, to interrupt the motor. If this fails too the movement is mechanically arrested, by means of buffers (not shown).

The pitch movement is typically limited to about 40° from the horizontal in either direction by the controlling software and the further movement limiting devices operate, typically, after a degree or two degrees of further movement, respectively.

Within the framework 2 is an inner frame 32 which is pivotable within the rest of the framework. The chamber 4 is secured to this inner frame 32. The inner frame is driven in an identical manner to the whole framework i.e. by an electric motor (mounted on the outer part of the framework 2) driving a toothed, silent chain which in turn drives an arcuate member, shown as 34. The damping and tilt limiting devices used are of the same type as for the whole framework. The movement of the inner frame simulates roll, and about 90° of movement from the horizontal is permitted in either direction.

The framework is lockable in a horizontal position, to allow personnel to safely enter the chamber. The lock for the whole framework 2, to prevent movement about the axis XX, as designated 36 in Figure 3. A similar lock (not shown) locks the inner frame with the outer part of the framework.

Each drive means is provided with an auxiliary drive referenced as 38 in Figure 1 (but not shown in Figure 3). The respective auxiliary drives are for emergency use in restoring the framework 2 and the inner frame 32 to the level position, at which they are l cked. The auxiliary drives each have a battery-perated motor and incorporate a change-over clutch mechanism and gear-box.

The scal of the apparatus is apparent from Figure 2 n which the cut-away portion reveals the int rior of the chamber, showing a control room large enough to accommodate five or six cr w under training.

CLAIMS

1. Apparatus for simulating the motion of a submarine, comprising a simulation chamber mounted for pivotal movement about first and second mutually perpendicular axes, and first and second drive means for effecting pivotal movement of the simulation chamber about the first and second axes respectively, each of the drive means comprising a part connected to the chamber and having an arcuate surface, and a belt or chain fixed at its ends to the arcuate surface and extending over the surface except in an intermediate region of the belt in which it leaves the arcuate surface and is engaged with a drive wheel driven by an electric motor.

2. Apparatus according to claim 1, wherein the chain or belt is a silent-running multi-chain.

3. Apparatus according to claim 2, wherein each drive means comprises a pair of idler rollers bearing against the arcuate surface at the two places where the chain or belt leaves the arcuate surface to engage the drive wheel.

4. Apparatus according to any preceding claim wherein each drive means is suspended from a supporting frame by resilient link members which serve to reduce noise and vibration transmission from the drive means to the chamber, and to tension the chain.

5. Apparatus according to any preceding claim, wherein means for limiting the pivotal movement of the chamber about the first and second axes is provided in the form of software controlling the motors.

6. Apparatus according to any of claims 1 to 5 wherein means for limiting the pivotal movement of the chamber about the first and second axes is provided in the form of microswitches operable to interrupt the respective motor or motors.

7. Apparatus according to any of claims 1 to 6 wherein means for limiting the pivotal movement of the chamber about the first and second axes is provided in the form of buffers.

8. Apparatus according to claims 5, 6 and 7, wherein the three movement-limiting means are operable in a sequence, the software providing the primary movement-limiting control, the microswitch control operating if the software control fails and the buffers arresting the movement if the microswitch control also fails.

9. Apparatus according to any preceding claim wherein harmonic reduction gearing is incorporated between the drive wheel and the motor.

10. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by
Croydon Printing Company (UK) Ltd, 3/87, D8991685.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.